PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : F04B 53/00, 15/00, B41J 2/175, B05B 9/04, F04B 53/10

A1

(11) International Publication Number: WO 95/07412

(43) International Publication Date: 16 March 1995 (16.03.95)

(21) International Application Number: PCT/IB94/00290

(22) International Filing Date: 9 September 1994 (09.09.94)

(30) Priority Data:
9318736.7 9 September 1993 (09.09.93) GB

(71) Applicant: ELOPAK SYSTEMS AG [CH/CH]; Cherstrasse 4, CH-8152 Glattbrugg (CH).

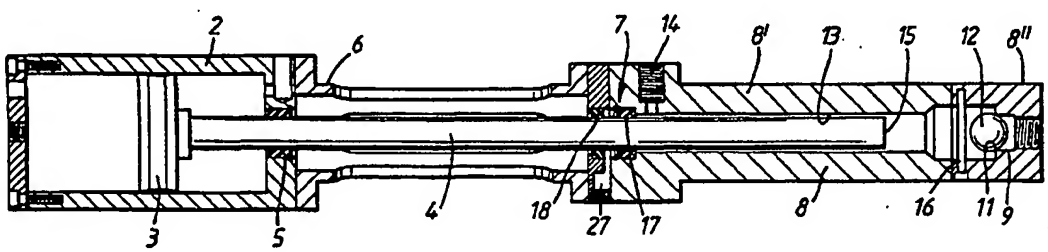
(72) Inventors: JANZ, Klaus; Am Buschweg 20, D-67374 Hanhofen (DE). RATAJCZAK, Gregor; Rudigerstrasse 9, D-67166 Otterstadt (DE).

(74) Agent: BURROWS, Anthony, Gregory; Business Centre West, Avenue One, Business Park, Letchworth Garden City, Hertfordshire SG6 2HB (GB).

(81) Designated States: CZ, HU, SK, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.

(54) Title: APPARATUS AND METHOD FOR PUMPING BINGHAM FLUIDS



(57) Abstract

A plunger pump for Bingham fluid, in particular a UV-curable ink, is designed to minimise mechanical stress in the ink during its flow from an inlet (9) at an axial end of a cylinder (8), through a non-return ball inlet valve (11, 12, 16) and a gap (13) between the plunger (4) and the cylinder (8), to an outlet (14). The gap (13) is closed at one end by sealing means (7) comprised of two channel-form sealing rings (17) and (18), the space between which communicates via a recycling outlet (27) with a reservoir for the Bingham fluid.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgystan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo			SE	Sweden
CH	Switzerland	KR	Republic of Korea	SI	Slovenia
CI	Côte d'Ivoire	KZ	Kazakhstan	SK	Slovakia
CM	Cameroon	LI	Liechtenstein	SN	Senegal
CN	China	LK	Sri Lanka	TD	Chad
CS	Czechoslovakia	LU	Luxembourg	TG	Togo
CZ	Czech Republic	LV	Latvia	TJ	Tajikistan
DE	Germany	MC	Monaco	TT	Trinidad and Tobago
DK	Denmark	MD	Republic of Moldova	UA	Ukraine
ES	Spain	MG	Madagascar	US	United States of America
FI	Finland	ML	Mali	UZ	Uzbekistan
FR	France	MN	Mongolia	VN	Viet Nam
GA	Gabon				

APPARATUS AND METHOD FOR PUMPING BINGHAM FLUIDS

This invention relates to a pump for and to a method of pumping Bingham fluid and to a method of obtaining liquid-tightness of a valve.

Various pumps are known for pumping Newton fluids.

FR-A-1195345 discloses a pump for liquids at high temperature, for example molten lead and molten aluminium, comprising a vertical piston-and-cylinder arrangement, with the piston reciprocable between a retracted position just above a lateral inlet to the cylinder and an advanced position near the bottom end wall of the cylinder, the molten liquid being forced up through one or more vertical grooves in the piston periphery to the level of a circular outlet groove in the cylinder leading to a lateral outlet from the cylinder. It is recommended that there should be a slight gap between the piston and the cylinder, the width of the gap being dependent upon the nature of the material of which the pump is made and the type of liquid to be pumped. In one example, in which the pump is of carbon steel and serves to lift molten lead, two vertical grooves, each of $1cm.^2$ cross-section, are provided in the peripheral surface of the piston, the volume stroke of the piston is approximately 1,000 $cm.^3$, and the play between the piston and the cylinder is of the order of 2mm, whilst the delivery is $720cm.^3$ per stroke.

In another version in FR-A-1195345, the groove(s) is/are omitted and the gap between the piston and the cylinder is enlarged to provide the necessary exit for the liquid when the piston is lowered. But in such case, the piston is provided with ribs or projections which correspond to the inlet opening(s) and which serve to close the same at the required moment.

US-A-2970546 discloses an apparatus whereby the liquid output, under pressure, of a centrifugal pump can be employed for obtaining a force for delivering the liquid at a higher pressure. The apparatus includes a double-acting piston-and-cylinder motor wherein a piston rod extends from both axial ends of a piston head. Each end of the piston

rod serves as the piston of a piston-and-cylinder pump for delivering the liquid under the higher pressure. In each piston-and-cylinder pump, there is a gap between the piston and the cylinder, a lateral inlet to the cylinder in the region of the end of the return stroke of the piston and communicating with the gap, and a lateral outlet from the cylinder in the region of the beginning of the return stoke. At the inner ends of the cylinders of the two pumps, the piston rod is closely encircled by the respective cylinders, but beyond the closely encircling end portions of the cylinders are respective stuffing boxes to prevent leakage of liquid towards the piston head. The inlets and outlets of the piston-and-cylinder pumps contain respective non-return ball valves. The centrifugal pump supplies the liquid under pressure to the motor by way of a change-over plug valve and to the piston-and-cylinder pumps.

US-A-3330217 discloses a double-acting pump designed for pumping corrosive and abrasive liquids. It comprises a cylinder containing a double-acting piston in the form of a plunger having a free end section of a diameter greater than that of its adjacent section. The free end section slides in sealing means which divides the cylinder into two pumping chambers and that adjacent section slides in a sealing means which is provided in a counterbore in the cylinder. The counterbore is disposed beyond a narrower-diameter bore which is at the inner end of the cylinder and through which that adjacent section extends. Each sealing means consists of a nest of chevron packing rings between suitably shaped, annular, metal parts. Provided co-axially at the outer end of the cylinder is an inlet, non-return, ball valve comprised of a collar screwed over the outer end of an outer tubular section of the cylinder, a valve seat ring slidably inserted into the outer end of that outer tubular section, a ball, and a retainer which traps the ball in co-operative relation with the seat. An annular shoulder formed inside that outer tubular section limits the inward movement of the valve seat ring and the retainer. The outer of the two pumping chambers has radial outlet ports in the region of

the end of the return stroke of the plunger and these lead into an encircling outlet duct which leads to a by-pass, non-return ball valve mounted on the outside of the cylinder. The by-pass ball valve is of similar construction to the inlet ball valve, except that the valve seat ring and the retainer are held in position by a helical compression spring rather than a shoulder. An outlet from the by-pass ball valve leads through the wall of the cylinder to the outer end of the second pumping chamber, the outlet from that chamber being at its inner end. In an example, the outside diameter of the free end section of the plunger is 4.27cm. (1.68 inches), the inside diameter of the outer tubular section of the cylinder at the outer pumping chamber is 4.45cm. (1.75 inches), the outside diameter of the adjacent section of the plunger is 3.01cm. (1.187 inches), and the inside diameter of an inner tubular section of the cylinder at the inner pumping chamber is 5.08cm. (2.00 inches). The piston is significantly smaller than the cylinder, has clearances relative to the walls of the cylinder and engages only the relatively flexible, chevron, packing rings. The liquid is transferred from one section of the cylinder to the other via the by-pass valve, whereby no porting is required in the piston and the same may be solid. It is stated that the pump, owing to the location of the radial outlet ports from the outer pumping chamber, the radial inlet ports into the inner pumping chamber, and the by-pass valve, is completely self-purging. In one version, the piston is formed of stainless steel. In another version, the piston is formed of ceramic material loaded solely in compression, whereby the ceramic material may be utilized for high pump pressures of 100bar (3,000 lbs./in.^{2}) or more.

DE-A-3448016 comprises a duplex plunger pump designed to pump liquids carrying abrasive particles, low viscosity sludges, emulsions and the like. Each pump plunger is coupled to the piston of a double-acting, hydraulic piston-and-cylinder motor controlled so that its pistons move in opposite directions. The hydraulic pressures acting on the

motors are governed by means of control valves actuated by a control module subject to the positions of the pump plungers, these positions being detected by electric sensors connected to the control module. The plunger pumps include respective cylinders at the outer ends of which are respective non-return ball inlet valves. In the regions of the ends of the return strokes of the respective plungers are lateral outlets from the pump cylinders, there being gaps between the plungers and their cylinders through which flows the liquid being pumped. The inner ends of the pump cylinders closely encircle the respective plungers, but beyond these ends are respective packings. Each packing appears to consist of two rings of elastomeric material spaced apart by a metal ring with a radial bore therein. In an alternative version, each pump and its motor are combined in such manner that the cylinder of the motor serves as the piston of the pump. In this version, the ball of the inlet ball valve, even in its fully open position, is very closely received in an encircling retainer. In a further version, the piston of the motor serves also as the plunger of the pump.

An article "A Modification to the Valve on a NZhR Pump for use up to 3kbar" on page 740 of Volume 30, No.3, May 1987, of "Instruments and Experimental Techniques" discloses a non-return ball valve mounted in the pump body. A threaded nut providing an outlet conduit is screwed into a threaded bore in the pump body, the bore leading from an outlet bore in the body. Seated in the outlet bore is an element of annular, lenticular shape of the same hardness as the ball and pressed sealingly against the pump body at the inner end of the threaded bore by the threaded nut. A helical compression spring acting between the threaded nut and the ball urges the ball sealingly against the lenticular element.

Fluids which show flow anomalies are classified as Bingham fluids. Irradiation cross-linkable inks and varnishes, such as UV-cured printing inks, are known examples of Bingham fluids. A property of flowing ink is

the ink inertia, known as thixotrophy. The viscosity of UV-cured printing inks, as measured by a rotary viscometer may vary between 15 and 23 Pas (Pascal-seconds). A known problem with the feeding of UV-cured printing inks is the change in the aggregate condition of the ink from fluid to solid as a result of relatively high mechanical shear stress. UV-cured printing inks also have the problem that they require relatively high manometric feed pressures of greater than 20 bar. Similar problems could arise with other irradiation cross-linkable inks and with irradiation cross-linkable, for example UV-cured, printing varnishes and lacquers.

It is believed that there are no pumps presently available commercially which do not produce significant solidification of irradiation cross-linkable liquid, in particular UV-cured printing inks during pumping, such as in printing machinery.

According to a first aspect of the present invention, there is provided an oscillatory pump for pumping a fluid, comprising inner means and outer means whereof the outer means bounds a chamber containing the inner means and whereof one is oscillatorily displaceable relative to the other with a return motion alternating with a pumping motion to displace said fluid relative to the other, a fluid inlet to said chamber, a fluid outlet from said chamber, a pumping surface portion of said one of said inner means and said outer means whereby pressure is applied directly to said fluid in said chamber, a rigid, annular, surface portion of said inner means extending away from said pumping surface portion, a rigid, annular, surface portion of said outer means facing the rigid surface portion of said inner means with a gap therebetween open at one end and whereby fluid under the pressure of said pumping surface portion can flow through said gap towards said outlet, said gap, when said one of said inner means and said outer means is at the beginning of said return motion, extending from the region of said inlet to the region of said outlet and being of a length substantially equal to the stroke of said one of said

inner means and said outer means, an inlet non-return valve in said inlet, an outlet non-return valve in said outlet, annular sealing means between said inner means and said outer means and sealing said gap at the other end of said gap, and driving means drivingly connected to said one of said inner means and said outer means for oscillating the same, characterised in that the pump is designed to pump a Bingham fluid such that the Bingham fluid does not undergo sufficiently high mechanical stress during its flow from said inlet *via* said inlet non-return valve and said gap to said outlet to cause significant change in the aggregate condition of the Bingham fluid.

According to a second aspect of the present invention, there is provided a method of pumping a fluid, comprising displacing one of inner means and outer means relative to the outer to displace said fluid and thereby cause said fluid to flow from an inlet, through an annular gap between said inner means and said outer means, to an outlet, characterised in that said fluid is a Bingham fluid and does not undergo sufficiently high mechanical stress during its flow from said inlet *via* said gap to said outlet to cause significant change in the aggregate condition of said Bingham fluid.

Owing to these aspects of the invention, Bingham fluids can be more successfully pumped than hitherto.

According to a third aspect of the present invention, there is provided a method of obtaining liquid-tightness of a metal valve closure member of a non-return valve with respect to a metal seating of the valve, comprising providing a metal valve closure member having a surface which is hard relative to the surface of said seating, and striking the relatively hard surface against the surface of said seating in substantially a desired closed position of said valve closure member, with sufficient force to displace portions of the surface of the seating.

This method is a simple yet effective way of obtaining liquid-tightness of a metal valve closure member with respect to a metal seating of the valve, in particular a

high-pressure valve.

In order that the invention may be clearly understood and readily carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a diagrammatic side elevation of an oscillatory pump for pumping UV-cured printing ink,

Figure 2 shows an axial section through the pump, and

Figure 3 is a detail of Figure 2.

Referring to the drawings, the pump includes a double-acting, pneumatic, piston-and-cylinder device 1 comprised of a cylinder 2 containing a disc-form piston 3. Fixed co-axially to the piston 3 is a plunger 4 of circular cross-section. The plunger 4 extends through a polyurethane seal 5, a co-axial apertured sleeve 6 and a sealing means 7 into a co-axial cylinder 8. The sleeve 6 is fixed firmly at its ends to the respective cylinders 2 and 8. Formed co-axially through the outer end of the cylinder 8 is an inlet 9 of circular cross-section for printing ink to be UV-cured. An outermost part 10 of the inlet 9 is internally threaded to receive an externally threaded connector for the ink supply. Upstream of the threading, the inlet 9 is formed with an annular seating 11 for a ball 12 of a non-return inlet valve 11,12,16. Apart from the seal 5 and items 18 and 25 of the sealing means 7, the parts of the pump are made of steel (or aluminium) and the steel ball 12 is surface-hardened. The plunger 4 may be coated with a material which rejects the printing ink, thereby to ensure that small particles of printing ink are not pulled into the sealing means 7 by the plunger 4. Upstream of the ball 12, the cylindrical, interior chamber of the cylinder 8 narrows slightly, but so as to leave a significant gap 13 between the rigid, cylindrical, peripheral internal surface of the chamber and the rigid, cylindrical, peripheral external surface of the plunger 4. The gap thus formed communicates with an internally threaded radial outlet 14 adjacent the sealing means 7. In the outlet 14 is a non-return outlet valve (not shown) which is spring-loaded but otherwise of the same construction as the inlet valve 11,12,16. By

means of the threading in the outlet 14, a discharge conduit can be connected, for discharge of the printing ink to be packaged or to be printed and cured. The free end of the plunger 4 has a flat radial surface 15 whereby pumping pressure is applied to the ink in the cylinder 8. It may be preferable for the surface 15 to be of a more streamlined form, for example of a convex, conical form, to minimize its production of shear stress in the ink. In the outer end position of the plunger 4, its surface 15 is just short of a ball-retaining screw 16 which extends transversely across the interior of the cylinder 8 at its widest place and is screwed partially into the peripheral wall of the cylinder 8. The screw 16 limits the extent of movement of the ball 12 away from the valve seat 11. With the ball 12 pressing against the screw 16 and thus fully open, the throughflow cross-sectional area for the Bingham fluid is constant from upstream of the ball 12 to downstream of the screw 16, so that the mass flow of the fluid over that same path is also constant, so avoiding mechanical stress in the fluid. The cylinder 8 is made in two cylindrical sections 8′ and 8′′ which are connected together after a liquid-tight contact of the ball 12 with the seating 11 has been achieved. This is obtained by simply placing the ball 12 on the seating 11, with the section 8′′ separate from the section 8′ and bearing with its outermost end surface upon a horizontal supporting surface and then striking the ball 12 axially at its top with sufficient force to cause its hardened surface to displace portions of the surface of the seating 11 to the extent that a close fit is achieved over an annular surface belt between the ball 12 and the seating 11. The pump is then assembled into substantially the form shown in the drawing. With the disc 3 at the inner end of its stroke, the surface 15 is just short of the screw 16 and a significant proportion of the volume of the chamber in the cylinder 8, in this case one fifth of its volume, is free to be occupied by ink. As the piston 3 moves towards its outer end position, ink is drawn in through the ball valve 11,12 and the plunger 4 retracts until its end surface 15 is

short of the sealing means 7. Then the piston 3 and the plunger 4 perform the pumping stroke, in which about four-fifths of the ink in the chamber is forced through the gap 13 and thence through the outlet 14, until the piston 3 arrives at its inner end position.

The annular gap 13 is of sufficient width that the mechanical shear stress on the ink between the plunger 4 and the cylinder 8 is insufficient to produce solidification of the ink. The minimum practical width of the gap depends upon the chemical structure of the ink and particle size of the pigment therein. The width is advantageously greater than 1mm. and preferably at least 2mm. It will be noted that, when the plunger 4 is at the beginning of its return stroke, the gap 13 extends from the region of the inlet 9 to the region of the outlet 14 and is of a length substantially equal to the stroke of the piston. The positioning of the ink inlet 9 and ink outlet 14 as shown, with the ink inlet in the region of the beginning of the return stroke of the plunger 4 and the outlet in the region of the end of that stroke, minimises dead volume in the ink chamber, where the ink may stagnate.

Referring particularly to Figure 3, the sealing means 7 comprises two channel-form sealing rings 17 and 18 spaced apart along the plunger 4. The annular mouth 19 of the ring 17 opens onto the gap 13 and the outer rim of the mouth 19 faces an annular internal shoulder 20 of the section 8′. The ring 17 is supported against the pressure of the ink in the gap 13 by a metal ring 21, itself supported by a Seeger circlip ring 22 engaged in an annular internal groove in the section 8′. Fixedly interposed co-axially between the sleeve 6 and the section 8 is a disc-form, metal ring 23 into which the sealing ring 18 is co-axially force-fitted. The ring 18 consists of a thin metal annular channel 24 closely receiving a thick annular channel 25 of the same material as the ring 17, which is of polyurethane. The annular space 26 between the sealing rings 17 and 18 is connected through an outlet 27 to a conduit leading to a reservoir for the ink to be pumped, whereby any ink leaking

past the sealing ring 17 is recycled. The pressure of the ink in the gap 13 and thus in the mouth 19 presses the respective side walls of the annular channel form of the ring 17 firmly against the plunger 4 and the section 8 and thus uses the pressure of the ink itself to seal against its own leakage. Similarly, the pressure of any ink which leaks into the space 26 presses the respective side walls of the annular channel form of the ring 18 firmly against the plunger 4 and the ring 23.

It will thus be appreciated that the pump, particularly the flow path from the inlet 9 through the inlet valve (11,12,16) and the gap 13 to the outlet 14 has been designed to minimize mechanical stress on the ink and thus avoid any significant change in the aggregate condition of the ink.

CLAIMS

1. An oscillatory pump for pumping a fluid, comprising inner means (4) and outer means (8) whereof the outer means (8) bounds a chamber containing the inner means (4) and whereof one (4) is oscillatorily displaceable relative to the other (8) with a return motion alternating with a pumping motion to displace said fluid relative to the other (8), a fluid inlet (9) to said chamber, a fluid outlet (14) from said chamber, a pumping surface portion (15) of said one (4) of said inner means (4) and said outer means (8) whereby pressure is applied directly to said fluid in said chamber, a rigid annular, surface portion of said inner means (4) extending away from said pumping surface portion (15), a rigid, annular, surface portion of said outer means (8) facing the rigid surface portion of said inner means (4) with a gap (13) therebetween open at one end and whereby fluid under the pressure of said pumping surface portion (15) can flow through said gap (13) towards said outlet (14), said gap (13), when said one (4) of said inner means (4) and said outer means (8) is at the beginning of said return motion, extending from the region of said inlet (9) to the region of said outlet (14) and being of a length substantially equal to the stroke of said one (4) of said inner means (4) and said outer means (8), an inlet non-return valve (11,12,16) in said inlet (9), an outlet non-return valve in said outlet (14), annular sealing means (7) between said inner means (4) and said outer means (8) and sealing said gap (13) at the other end of said gap (13), and driving means (1) drivingly connected to said one (4) of said inner means (4) and said outer means (8) for oscillating the same (4), characterised in that the pump is designed to pump a Bingham fluid such that the Bingham fluid does not undergo sufficiently high mechanical stress during its flow from said inlet (9) <u>via</u> said inlet non-return valve (11,12,16) and said gap (13) to said outlet (14) to cause significant change in the aggregate condition of the Bingham fluid.

2. A pump according to claim 1, wherein said inlet non-

return valve (11,12,16) comprises an annular valve seat (11), a valve closure member (12) in the form of a ball (12) for co-operating with said seat (11), a substantially cylindrical internal surface encircling said ball (11), and ball-retaining means (16) encircled by said internal surface and limiting the extent of movement of said ball (12) away from said valve seat (11), and wherein, with said ball (12) fully open and thus bearing against said retaining means (16), the throughflow cross-sectional area for said Bingham fluid is substantially constant from upstream of said ball (12) to downstream of said ball (12) and said retaining means (16).

3. A pump according to claim 2, wherein said retaining means (16) comprises an elongate element (16) extending from one side to the opposite side of said internal surface.

4. A pump according to any preceding claim, wherein said sealing means (7) comprises a flexible annular seal (18) of channel form, with the annular mouth (19) of the channel opening onto said gap (13).

5. A pump according to any one of claims 1 to 3, wherein said sealing means (7) comprises two annular seals (17,18) spaced apart along said inner means (4), a conduit connecting the space between the seals (17,18) to a reservoir for Bingham fluid to be pumped.

6. A pump according to any preceding claim, wherein an external peripheral surface of said inner means (4) is coated with a material which rejects said Bingham fluid.

7. A pump according to any preceding claim, wherein said pumping surface portion (15) is of a more streamlined form than a flat, radial surface.

8. A pump according to claim 7, wherein said pumping surface portion (15) is of a convex, conical form.

9. A method of pumping a fluid, comprising displacing one (4) of inner means (4) and outer means (8) relative to the outer (8) to displace said fluid and thereby cause said fluid to flow from an inlet (9), through an annular gap (13) between said inner means (4) and said outer means (8), to an outlet (14), characterised in that said fluid is a Bingham

fluid and does not undergo sufficiently high mechanical stress during its flow from said inlet (9) via said gap (13) to said outlet (14) to cause significant change in the aggregate condition of said Bingham fluid.

10. A method according to claim 9, wherein said Bingham fluid flows through a non-return ball inlet valve (11,12,16) in said inlet (9) and the mass flow of the Bingham fluid is substantially constant during its flow from upstream of the ball (12) of the valve (11,12,16) to downstream of the ball (12) and ball-retaining means (16) which limits the extent of movement of the ball (12) away from a valve seat (11).

11. A method according to claim 9 or 10, and further comprising recycling Bingham fluid which leaks past annular sealing means (7) encircling said inner means (4) and closing an end of said gap (13).

12. A pump or a method according to any preceding claim, wherein said Bingham fluid is an irradiation cross-linkable liquid.

13. A method of obtaining liquid-tightness of a metal valve closure member (12) of a non-return valve (11,12,16) with respect to a metal seating (11) of the valve (11,12,16), comprising providing a metal valve closure member (12) having a surface which is hard relative to the surface of said seating (11), and striking the relatively hard surface against the surface of said seating (11) in substantially a desired closed position of said valve closure member (12), with sufficient force to displace portions of the surface of the seating (11).

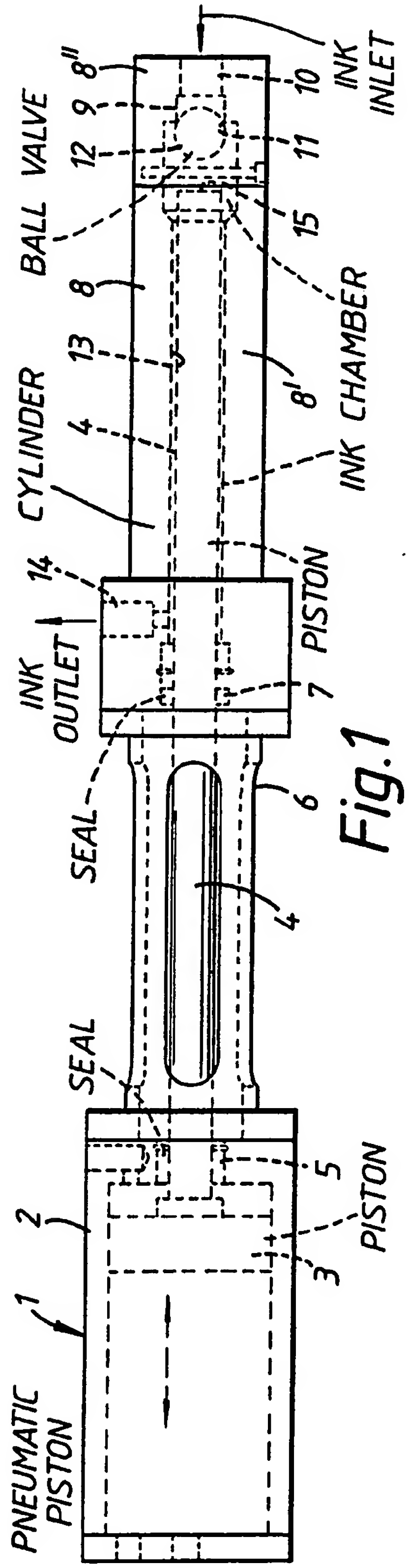

INK INLET
BALL VALVE
CYLINDER
INK CHAMBER
PISTON
INK OUTLET
SEAL
SEAL
PISTON
PNEUMATIC PISTON
1
2
3
4
5
6
7
8
8'
8''
9
10
11
12
13
14
15

Fig.1

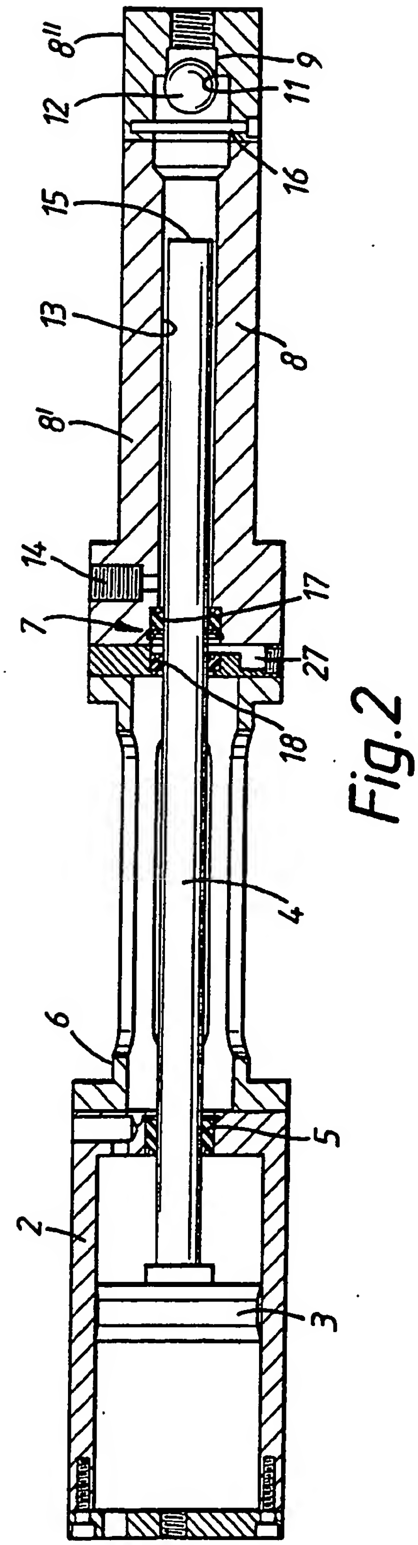

2
3
4
5
6
7
8
8'
8''
9
11
12
13
14
15
16
17
18
27

Fig.2

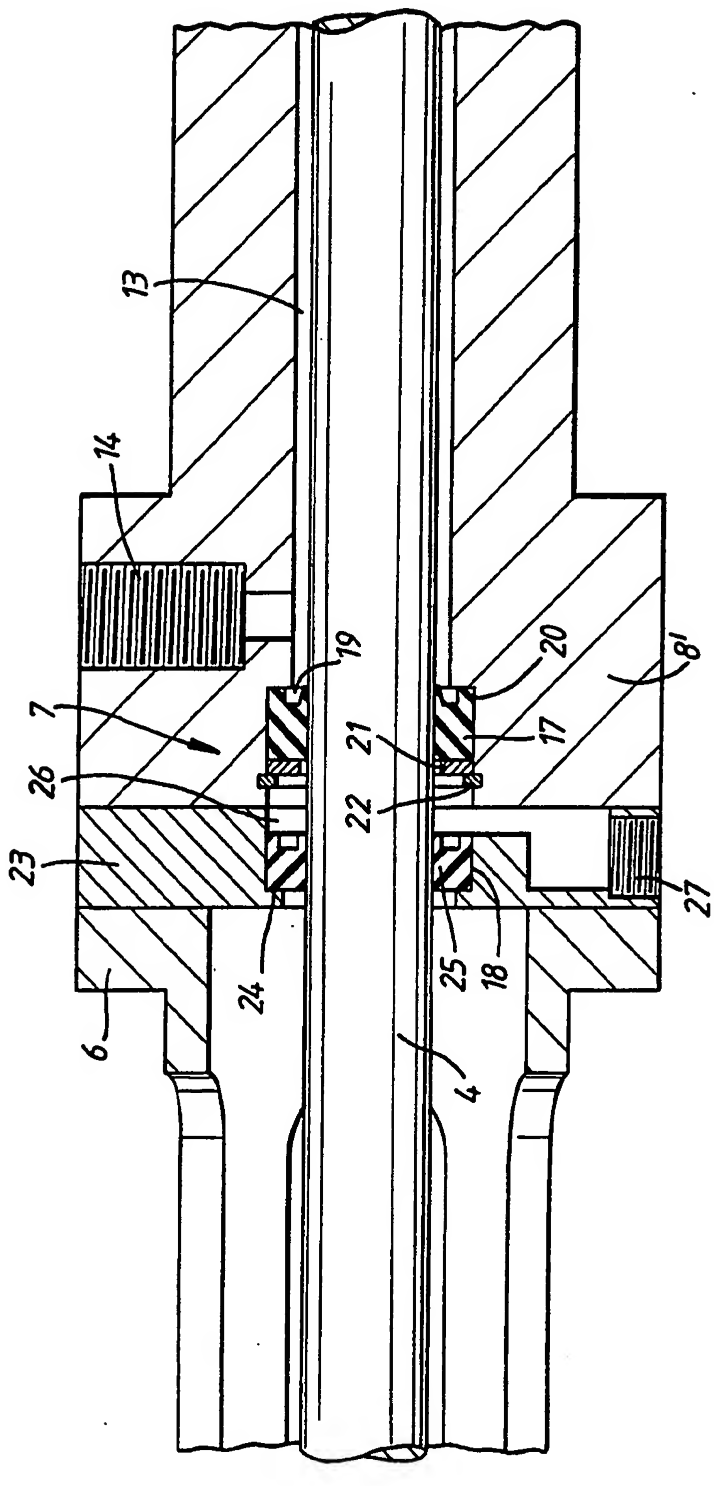


Fig.3

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 F04B53/00 F04B15/00 B41J2/175 B05B9/04 F04B53/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 F04B B41J B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A,3 330 217 (BAUR) 11 July 1967 cited in the application see the whole document ---	1-6,9-12
P,Y	DE,U,93 08 066 (LINCOLN) 9 September 1993 see the whole document ---	1-6,9-12
A	US,A,2 440 216 (ANDERSON) 4 June 1945 see figures 1,9 ---	7,8
A	INSTRUMENTS AND EXPERIMENTAL TECHNIQUES, vol.30, no.3, May 1987, NEW YORK US page 740 POLANDOV ET AL. 'A MODIFICATION TO THE VALVE ON A NZHR PUMP FOR USE UP TO 3 KBAR' cited in the application --- -/--	13

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 November 1994	25. 11. 94

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Von Arx, H

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DE,A,34 48 016 (OBERMANN) 12 June 1986 cited in the application see page 7, paragraph 1 see page 15, paragraph 2; figures ---	1,3,5, 7-9
A	FR,A,1 195 345 (MONTECATINI) 17 November 1959 cited in the application see page 1, right column, last paragraph - page 2, left column, paragraph 8; figures ---	1,3
A	US,A,2 970 546 (WHITE) 4 February 1961 cited in the application see column 2, line 37 - line 69; figure 1 ---	1,3
A	DE,A,15 50 530 (SCHLECHT) 9 October 1969 see the whole document -----	13

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
US-A-3330217		NONE		
DE-U-9308066	09-09-93	DE-A-	4305308	25-08-94
US-A-2440216		NONE		
DE-A-3448016	12-06-86	DE-A-	3428629	13-02-86
		AU-A-	4720685	07-03-86
		WO-A-	8601260	27-02-86
		EP-A-	0188611	30-07-86
FR-A-1195345		NONE		
US-A-2970546		NONE		
DE-A-1550530	09-10-69	NONE		